Thin metal films as absorbers for infrared sensors

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Abstract

In order to achieve the maximal sensitivity of a thermal IR sensor, the incident light must be efficiently absorbed. This may be done either by the sensor material with its own electrodes or by an additional absorber structure. Freely suspended thin metal films are known to act as wide-band absorbers for IR radiation. Prepared on the solid surface of the sensor, the absorbing properties of the metal layer are, however, strongly influenced by the dielectric function of the sensor material. Results are presented for thermoelectric and pyroelectric sensors. For the thermoelectric sensor, a 400 nm thick silicon layer is used as a support for the absorbing silver film with a sheet resistance of 150 Ω/□, evaporated onto the rear side of the silicon layer. This absorber has an absorbance of nearly 50% independent of the wavelength over the whole IR range. For pyroelectric sensors two examples of absorbers on PVDF are presented. The first is a broad-band absorber and has an absorbance of about 50% within the wavelength region 3–200 μm. The other is a selective absorber and has an absorbance of about 90% within the region 7–15 μm. The selective absorber is completely opaque and can be realized by means of a PVDF film with a thickness of about 2 μm, covered on both sides by metal films. This structure may serve as an excellent absorber for a crystalline pyroelectric sensor.

1. Introduction

The detection and measurement of infrared radiation are gaining increasing importance in various areas. Detectors working at ambient temperature are of special interest, as expensive cooling apparatus is avoided. Thermal infrared detectors are used in a wide field of applications, starting from measurement devices, where the highest sensitivity and performance are essential, to consumer applications, where cheap and simple manufacture of the sensors is the most important criterion. Infrared sensors are used as detectors in measuring devices like Fourier spectrometers, for gas analysis, for thermal imaging, and for laser beam characterization. All these applications are used on Earth and in space satellites. Simple infrared sensors have found mass applications in consumer products like fire alarms and intruder detectors [1]. The spectral sensitivity of the sensor for the incoming radiation is determined by its application. For spectrometer applications a broadband sensitivity is desirable, while for consumer applications the sensor should have a selective sensitivity for radiation in the wavelength region 7–15 μm.

Sensors like photomultipliers or photoconductors are sensitive only within a limited wavelength region; they have an upper limit for the wavelength of detectable radiation. In contrast to these quantum detectors, thermal sensors like thermoelectric or pyroelectric sensors act as detectors for the entire radiation intensity. Provided with an appropriate absorber structure, they may work over a wide spectral range.

Thin metal films are known to act as wide-band absorbers for IR radiation with a very small heat capacity. A freely suspended metal film can absorb up to 50% of the incident radiation [2]. The absorbance is independent of the wavelength of the radiation, as long as the radiation frequency is smaller than the reciprocal collision time of the electrons in the metal film. The application to radiation sensors requires the deposition of the absorbing metal films on the solid surface of the sensor. The absorbing properties of the metal layer are, however, strongly influenced by the dielectric function of the sensor material [3].

In this paper the optical properties of thin metal films on a dielectric substrate are discussed for selected substrates with different kinds of dielectric functions. Absorber structures for thermoelectric and pyroelectric sensors are given. For the thermoelectric sensor, a broad-band absorber has been realized. This absorber has an absorbance of nearly 50% independent of the wavelength over the whole IR range. Two examples of absorbers for pyroelectric detectors with polyvinylidenefluoride (PVDF) are presented. The first is a

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